The Lakes of Maple Valley and Covington

A Report on Monitoring Results for the 2011 Water Year at Lake Lucerne, Pipe Lake, and Lake Wilderness

Lake Wilderness, July 2011 *photo by Sally Abella, Lake Stewardship Program*

Prepared for the Cities of Maple Valley and Covington
by the King County Lake Stewardship Program

December 8, 2011

King County

The City of MAPLE VALLEY

City of Covington

Overview

The King County Lake Stewardship Program and its predecessor programs have worked with volunteer monitors on all three lakes that are currently completely or partially within the Cities of Maple Valley and Covington. Lake Lucerne data has been collected since the 1980s, while Pipe, and Wilderness Lakes have been monitored since the 1970s. The water quality data indicate that the three lakes currently range from low to moderate in primary productivity, with generally good water quality.

This report refers to two common measures used to predict water quality in lakes: the Trophic State Index or TSI (Carlson 1977), and the nitrogen to phosphorus ratio (N:P). The TSI and N:P ratios were calculated from the data collected through the King County Lake Stewardship (KCLSP) volunteer monitoring program.

TSI values are derived from a regression that relates values of a parameter such as total phosphorus, chlorophyll *a* or Secchi transparency to the predicted algal bio-volume, assigning a number on a scale of 0 to 100. This scale can be used to compare water quality over time and between lakes. The TSI values at each of the lakes in Maple Valley have been relatively stable for at least the last 13 years, with no verified trends of declining water quality evident for any of the lakes.

The discussion in this report focuses on the 2011 water year. Specific data used to generate most of the charts in this report can be downloaded from the King County Lake Stewardship data website at:

http://your.kingcounty.gov/dnrp/wlr/water-resources/small-lakes/data/default.aspx

Or it can be provided in the form of excel files upon request.

Lake Lucerne

While a small number of samples were taken in the 1970s, consisitent volunteer monitoring began at Lake Lucerne in the 1980s and continued through 2011, with a gap in the early 1990s. The data indicate that this 16-acre lake is relatively low in primary productivity (oligotrophic - mesotrophic) with good to excellent water quality.

Lake Lucerne has no public access boat launch, but does have a history of both milfoil and hydrilla infestations for which eradication efforts have been underway since 1995. Milfoil has been eradicated, and the last hydrilla plant was found six years ago. Lake Lucerne has not been treated with the herbicide fluridone (Sonar PR ™) since 2008 and had no residual levels of the herbicide when last tested in spring 2010. The year 2011 was the second year that adjoining Pipe Lake was no longer treated. King County and its contractor will monitor as aquatic plants begin to recover in the shallow water zones of the lake. Lake users and residents should keep a close eye on aquatic plants growing nearshore to catch new or expanding patches of noxious weeds.

Physical Parameters

No precipitation or lake level data were collected for Lake Lucerne in 2011.

Secchi transparency is a common method used to assess and compare water clarity. It is a measure of the water depth at which a black and white disk disappears from view when lowered from the water surface.

Volunteers collected Secchi transparency and temperature data from early May through late October during the "Level 2" monitoring season when volunteers collect water samples for laboratory analysis. Secchi transparency ranged between 2.4 and 5.5 meters (m) from May through October (Figure 1), averaging 3.9 m, which is somewhat more shallow than has been typical of Lake Lucerne.

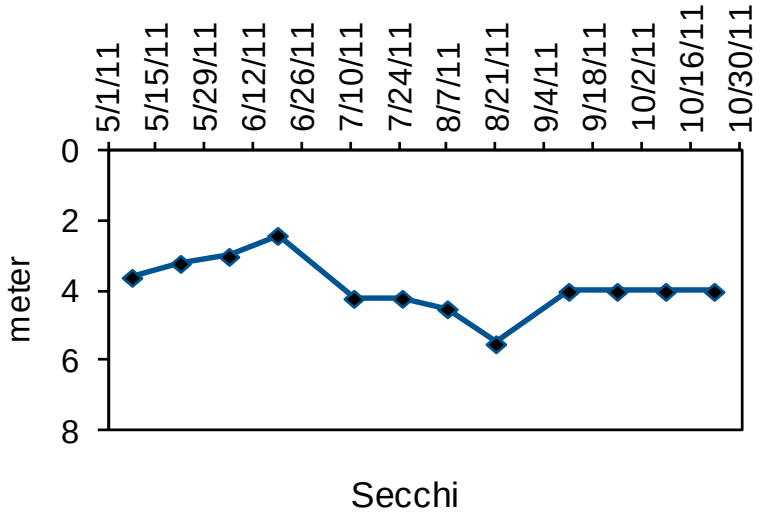

Figure 1. WY 2011 Lake Lucerne Secchi Depth

Surface water temperatures reached ranged from 13.0 to 25. degrees Celsius, with an average of 19.9 degrees Celsius, which was in the upper third of the monitored lakes in 2011 and was slightly warmer than in 2010 (Figure 2). Maximum temperatures were not reached until the end of August, likely due to the wet and cold spring through early summer that the Puget Sound region experienced.

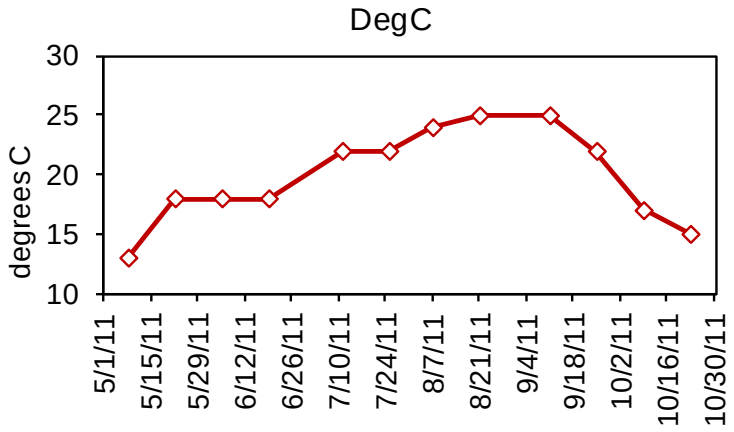

Figure 2. WY 2011 Lake Lucerne Temperature

Nutrient and Chlorophyll Analysis (Lake Lucerne)

Phosphorus and nitrogen are naturally occurring elements necessary in small amounts for both plants and animals. However, many actions associated with residential development can increase concentrations of these nutrients beyond natural levels. In lakes of the Puget Sound lowlands, phosphorus is often the nutrient in least supply, meaning that biological productivity is often limited by the amount of available phosphorus. Increases in phosphorus concentrations can lead to more frequent and dense algae blooms – a nuisance to residents and lake users, and a potential safety threat if blooms become dominated by cyanobacteria (bluegreen algae) that can produce toxins. Samples collected by volunteers are analyzed for total phosphorus (TP) and total nitrogen (TN) concentrations at one meter depth.

TN concentrations began higher in spring and tapered off until fall with little variation between early summer and fall. Phosphorus was generally stable at low levels throughout the season (Figure 3).

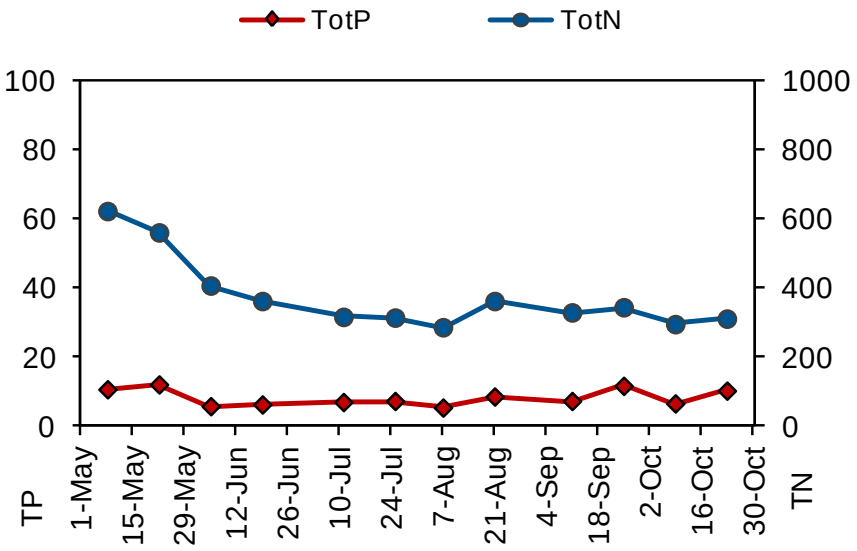

Figure 3. WY 2011 Lake Lucerne Total Phosphorus and Total Nitrogen Concentrations

The ratio of nitrogen (N) to phosphorus (P) can be used to determine if conditions are favorable for the growth of cyanobacteria that can impact beneficial uses of the lake. When N:P ratios are near 20 or below, cyanobacteria can have an advantage in dominance of the algal community due to their ability to take nitrogen from the air. Total phosphorus and total nitrogen remained in relatively constant proportion to each other through the sampling period, ranging from 29.7 to 71.4 with an average of 47.7, which suggests generally poor conditions for growing nuisance bluegreen algae at Lake Lucerne.

Chlorophyll *a* concentrations remained relatively stable throughout the season, except for a maximum in spring and a distinct rise at the end of October. These seasonal changes represent a peak in phytoplankton activity in spring when light levels increase and a growth increase in late fall when the water in the lake mixed thermally, bringing nutrients up from the hypolimnion. Pheophytin, which is degraded chlorophyll, was at levels near or below detection levels throughout the period (Figure 4).

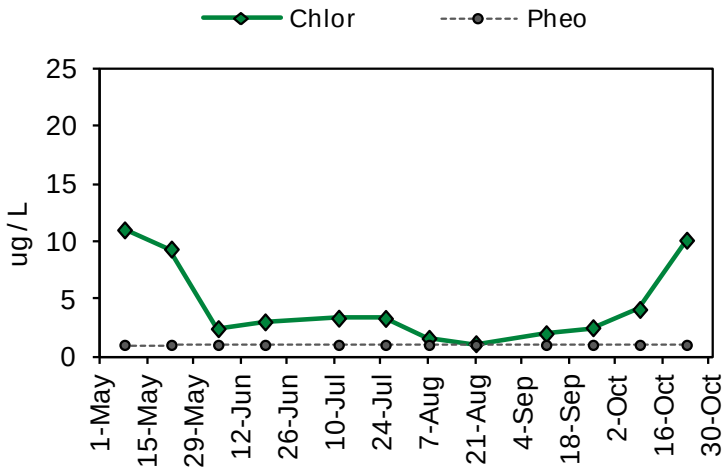

Figure 4. WY 2011 Lake Lucerne Chlorophyll *a* and Pheophytin concentrations

Temperature profile data indicate that thermal stratification was present by mid-May and persisted through the summer (Table 1).

Table 1. Lake Lucerne Profile Sample Analysis Results. Sample values below minimum detection level are marked <MDL.

Lake name	Date	Secchi	Depth	DegC	Chlor-a	Pheo	Total N	NH3	Total P	OPO4	UV254	Total Alk
Lucerne	5/22/11	3.2	1	18.0	9.3	<MDL	0.561	0.007	0.0120	<MDL	0.099	29.8
Lucerne	5/22/11		5	11.0	5.4	<MDL	0.571		0.0208			
Lucerne	5/22/11		9	8.0			0.554	0.007	0.0159	0.0029		
Lucerne	8/21/11	5.5	1	25.0	1.1	<MDL	0.362	0.012	0.0085	<MDL	0.081	34.4
Lucerne	8/21/11		5	9.0	1.9	<MDL	0.304		0.0083			
Lucerne	8/21/11		9	5.0			0.609	0.134	0.0339	<MDL		

Concentrations of total phosphorus (Total P) in the deep water remained relatively low, though the deep water concentration did increase by the end of August. The amount of orthophosphate (OPO4) also was low on both dates, indicating there was no major release of phosphorus from the sediments. In addition very little ammonia was found in the deep water over the spring but some was found in late summer suggesting the deep water remained relatively well-oxygenated for the majority of the sampling season. This suggests that internal loading of phosphorus to the lake was relatively minor and anoxic conditions did not become established in the deeper water of the lake.

Chlorophyll *a* data (Chlor) indicate that algae were more or less equally distributed through the upper depths of the water column at fairly low concentrations, with little degraded chlorophyll present (pheophytin). There were more algae in the spring than in the late summer, which is confirmed by the chlorophyll measurements made throughout the season (Figure 4).

Alkalinity, also known as acid neutralizing capacity or buffering capacity, was relatively low, meaning the lake is sensitive to acidification. The water color (UV254) was also very low, indicating that dissolved organic carbon was not abundant in the lake water.

TSI Ratings (Lake Lucerne)

A common method of tracking water quality trends in lakes is by calculating the "trophic state index" (TSI), developed by Robert Carlson in 1977. TSI indicators predict the biological productivity of the lake based on water clarity (Secchi) and concentrations of TP and chlorophyll *a* (see discussion in the overview).

The 2011 TSI values for chlorophyll and Secchi were in the low-mid range of mesotrophy and TSI-TP was significantly lower (Figure 5). The average of the three values was 39.9; putting Lake Lucerne in the upper range of oligotrophy, low range of mesotrophy; indicating it is fairly low in primary productivity. The relationships between the 3 different indicators have held relatively steady for the past 4 years, with the phosphorus concentrations predicting low algae populations.

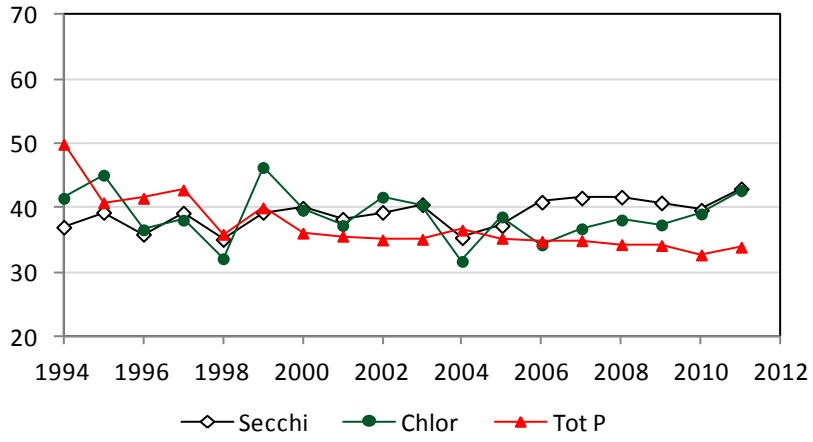

Figure 5. Lake Lucerne Trophic State Indicators

Conclusions and Recommendations

Based on monitoring data, water quality in Lake Lucerne appears to have been stable over the period measured. High N:P ratios indicate conditions are not favorable for nuisance bluegreen algae blooms. Watershed development is occurring in the Lake Lucerne basin, and the lake should continue to be monitored to insure that conditions from increased development do not affect the water quality of the lake. With the sunset of herbicide treatments as part of the hydrilla eradication project in both Pipe and Lucerne Lakes, the city and the residents around the lake should be vigilant in looking for invasive aquatic plants colonizing the lake, such as Eurasian watermilfoil, in addition to the return of native aquatic plants.

Pipe Lake

Volunteer monitoring began at Pipe Lake in the 1970s and has been continuous since the early 1990s. The data indicate this 52-acre lake is fairly low in primary productivity (high oligotrophic) with very good water quality. Nearly 55% of the shoreline of Pipe Lake is in the City of Maple Valley. The remainder is in the City of Covington.

Pipe Lake has no public access boat launch, but there is a community boat launch at Cherokee Bay. The lake is connected to Lake Lucerne by a short, shallow channel and has a history of both milfoil and hydrilla infestations for which eradication efforts have been funded by government agencies since 1995. Eurasian watermilfoil has been eradicated, and the last plant of hydrilla was found in 2006. The year 2011 is the second one in which no herbicide was applied to the lake. Instead, diving and snorkeling surveys focused on finding any remaining hydrilla and documenting the return of native aquatic plants to the lake. Residents should watch aquatic plants growing nearshore to catch growing patches of milfoil, Hydrilla or other noxious weeds. To date no hydrilla has been found and no other submerged noxious aquatic weeds have been identified.

Physical Parameters

No precipitation or lake level data were collected for Pipe Lake in 2011.

Volunteers collected Secchi transparency and temperature data from early May through late October during the "Level 2" monitoring season when volunteers collect water samples for laboratory analysis. Secchi transparency from late May through October ranged from 3.5 to 5.5 m, averaging 5.0 m, which placed it among the 3 clearest lakes measured out of 12 during the 2011 monitoring (Figure 1).

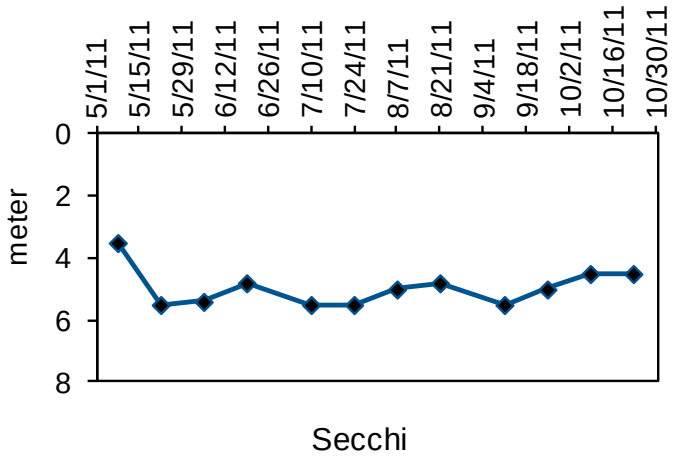

Figure 1. WY 2011 Pipe Lake Secchi Depth

Water temperatures for the same period ranged from 18.0 degrees Celsius to a peak of 23.8 degrees Celsius with an average of 20.7, which was the warmest of all monitored lakes in 2011, but which was cooler than the previous year (Figure 2). There is some

question as to the last two temperature readings staying at 19.0 C when other area lakes temperatures decreased throughout the month of October. It is possible that the thermometer malfunctioned and needs to be repaired or replaced.

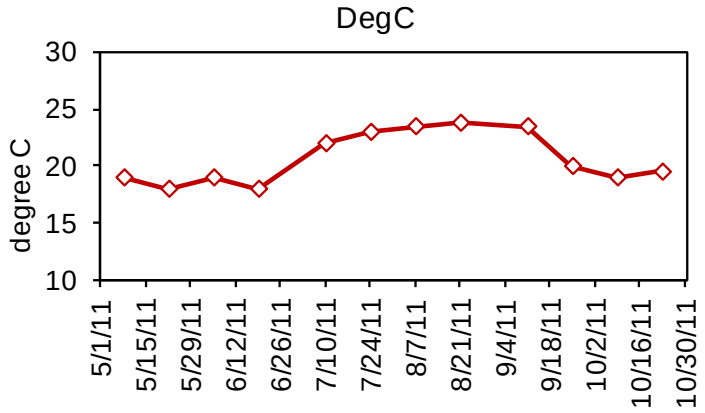

Figure 2. WY 2011 Pipe Lake Temperature at 1m

Nutrient and Chlorophyll Analysis (Pipe Lake)

Phosphorus and nitrogen are naturally occurring elements necessary in small amounts for both plants and animals. However, many actions associated with residential development can increase concentrations of these nutrients beyond natural levels. In lakes of the Puget Sound lowlands, phosphorus is often the nutrient in least supply, meaning that biological productivity is often limited by the amount of available phosphorus. Increases in phosphorus concentrations can lead to more frequent and dense algae blooms – a nuisance to residents and lake users, and a potential safety threat if blooms become dominated by species that can produce toxins. Samples collected by volunteers are analyzed for total phosphorus (TP) and total nitrogen (TN) concentrations at one meter depth.

Total phosphorus and total nitrogen showed only slight variations through the sampling period. Both nitrogen and phosphorus declined from early May through early August and there was a slight increase at the end of September and again in late October (Figure 3). The N:P ratio ranged from 37.3 to 73.4, averaging 53, which is similar to previous years and indicated generally poor conditions for nuisance bluegreen growth.

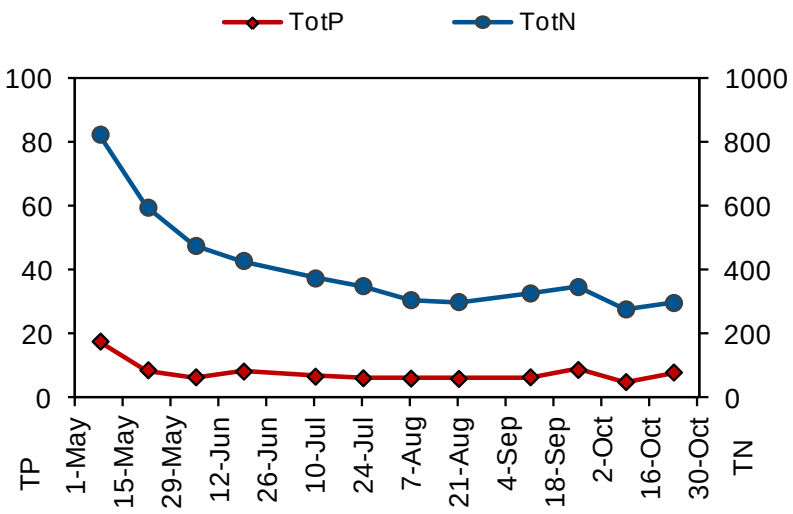

Figure 3. 2011 Pipe Lake Total Phosphorus and Total Nitrogen Concentrations

The chlorophyll level dropped significantly in early May, then rose slightly in June, but decreased again and remained very low through July and August. Concentrations climbed again in October with fall turnover. Pheophytin, which is a degradation product of chlorophyll, stayed at or below the minimum detection level. This indicates phytoplankton concentrations may have been high at the end of spring but remained low in Pipe Lake throughout the summer and began to climb again in fall. This is very similar to what was observed in Lake Lucerne over the season.

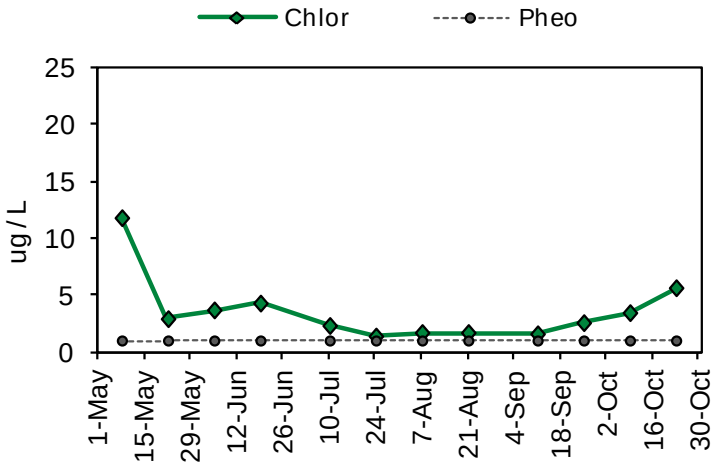

Figure 4. WY 2011 Pipe Lake Chlorophyll *a* and Pheophytin concentrations

Profile temperatures were not collected during the first sampling date, but the August thermal profile indicated stratification was present and the cool temperature of the deep water supported the notion that it had been present for quite awhile. The May profile indicated that high total phosphorus and ammonia (NH3) were present in the bottom water. This indicates that low oxygen conditions were becoming established in the bottom meters of Pipe Lake by that time, likely resulting in some phosphorus release from the bottom sediments. By August, it appeared that anoxic conditions had indeed set

up in the bottom water with high bottom readings of TP, soluble reactive phosphorus (OPO4) and ammonia. The anoxic conditions likely contributed to internal phosphorus cycling from the lake sediments. Chlorophyll *a* data indicated that algae were approximately equivalent in May and increasing in the metalimnion in the August sample.

Table 1. Pipe Lake Profile Sample Analysis Results. Sample values below minimum detection level are marked <MDL.

Lake name	Date	Secchi	Depth	DegC	Chlor-a	Pheo	Total N	NH3	Total P	OPO4	UV254	Total Alk
Pipe	5/22/11	5.5	1	18.0	2.9	<MDL	0.597	0.009	0.0087	<MDL	0.098	29.5
Pipe	5/22/11		10		1.7	<MDL	0.646		0.0093			
Pipe	5/22/11		19				0.732	0.007	0.0292	<MDL		
Pipe	8/21/11	4.8	1	23.8	1.7	<MDL	0.301	<MDL	0.0060	<MDL	0.076	32.6
Pipe	8/21/11		10	8.0	6.4	2.0	0.680		0.0109			
Pipe	8/21/11		19	6.5			1.160	0.959	0.2550	0.0413		

Alkalinity, also known as acid neutralizing capacity or buffering capacity, was relatively low and essentially equivalent to adjoining Lake Lucerne, making it sensitive to pH changes. Water color measurements (UV254) also were very low, contributing to water clarity and indicating that dissolved organic carbon was not an important component in the lake.

TSI Ratings (Pipe Lake)

A common method of tracking water quality trends in lakes is by calculating the "trophic state index" (TSI), developed by Robert Carlson in 1977. TSI indicators predict the biological productivity of the lake based on water clarity (Secchi) and concentrations of TP and chlorophyll *a* (see discussion in the overview).

The 2011 TSI indicators for chlorophyll *a* and Secchi were very close to each other in the lower range of mesotrophy. The TSI –TP indicator was in the lower oligotrophic range (Figure 5). Pipe Lake is solidly in the range for oligotrophy, and it appears to have been essentially stable since 2003. Looking at the progression of the annual TSI-TP values over the entire range of monitoring, there appears to be a decreasing trend. However, the statistical basis for this is not strong, with the correlation coefficient of linear regression being quite low.

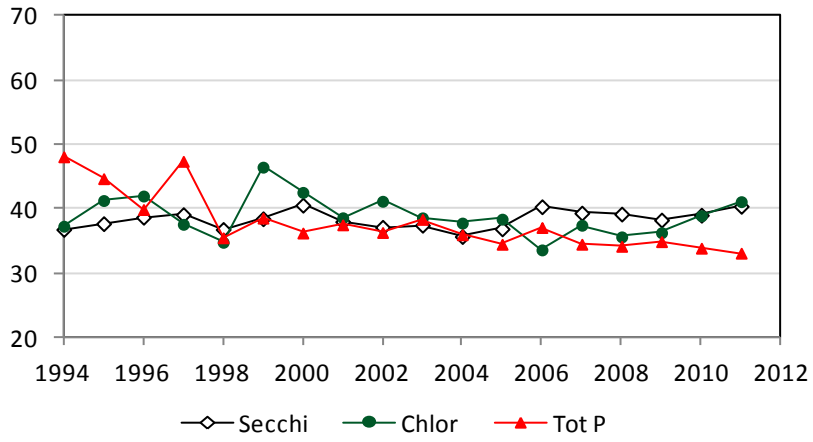

Figure 5. Pipe Lake Trophic State Indicators

Conclusions and Recommendations

Based on monitoring data, water quality in Pipe Lake appears to have been stable over the last 8 years at least and perhaps longer, although the values were more variable in the earlier years of the monitoring. High N:P ratios indicate conditions in the lake are not favorable for nuisance bluegreen algae blooms. With the sunset of the hydrilla eradication project, the city and the residents around the lake should be vigilant in looking for invasive aquatic plants, such as Eurasian watermilfoil and Hydrilla, as the aquatic vegetation returns to the lake.

Lake Wilderness

Volunteer monitoring began at Lake Wilderness in the mid 1970s and has continued through 2011, with few gaps over time. The data indicate this 67-acre lake is moderate in primary productivity (mesotrophic) with generally good water quality.

Of the three lakes, Wilderness is the only one that has an active "Level I" volunteer, whose monitoring consists of daily precipitation and water level readings and weekly measurements of water temperature and clarity throughout the entire water year. All 3 lakes have "Level II" volunteers who go out on the lake every two weeks between May and October to take water samples for analysis and measure temperatures and clarity as well.

Lake Wilderness has a public access boat launch and a large city park, as well as a regional trail that runs along the east side of the lake. There is a history of Eurasian watermilfoil infestation, with control activities funded and monitored by the community and the city of Maple Valley. Residents have been active stewards of the lake through the years and should continue to watch for new patches of Eurasian milfoil, as well as other noxious weeds that might invade the lake, such as Brazilian elodea.

Physical Parameters

Excellent records of precipitation and water level were kept over the year (Figure 1). The lake level, which generally follows the regional pattern of winter high - summer low stands, increased in the winter and then began to decrease in early spring. While there was a slight decrease in the lake level through the summer, the decrease was not very significant and in fact remained fairly steady throughout the year, unlike some years in the past when large swings in lake level have been observed. There was a difference of 37 cm between the highest and lowest stands during the year, distinctly less than the difference recorded for many previous years. This can be attributed to the wet spring and early summer that was part of the La Nina weather pattern in 2011.

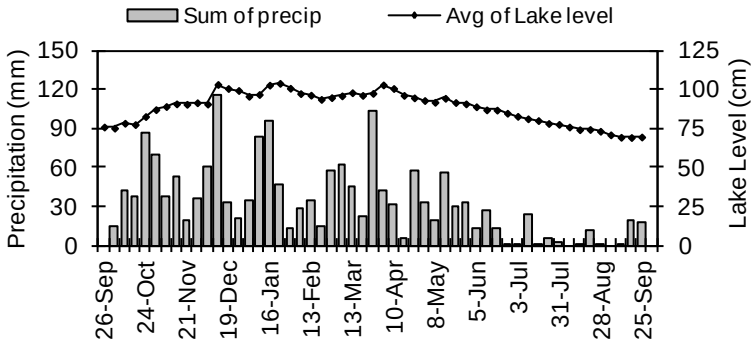

Figure 1. WY 2011 Lake Wilderness Level and Precipitation

Secchi transparency ranged from 1.5 to 8.7 m through the year (Figure 2). The summer average of 5.4 m placed it among the clearest of the small lakes monitored in 2011. However, water clarity fluctuated throughout the season. The lower Secchi readings in

the summer appear to be occurring in conjunction with the high chlorophyll levels seen in the lake in early spring and late summer/fall. There could be something similar occurring in the winter when the Secchi readings were lower as well.

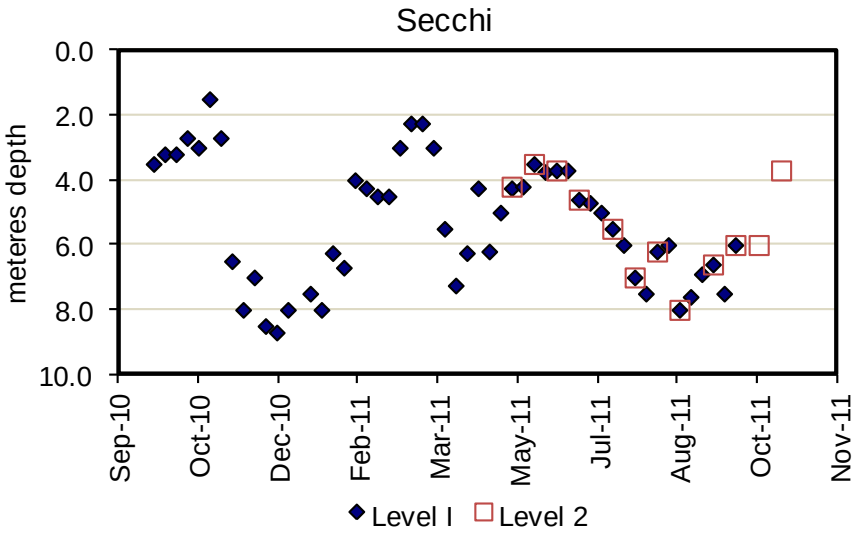

Figure 2. WY 2011 Lake Wilderness Secchi

Annual water temperatures ranged from 4.5 to 23.0 degrees Celsius (Figure 3), with a summer average of 18.8 degrees Celsius, placing Lake Wilderness in the middle group of the 12 lakes monitored in 2011. The pattern is typical of Puget Sound lowland lakes of winter lows and summer highs.

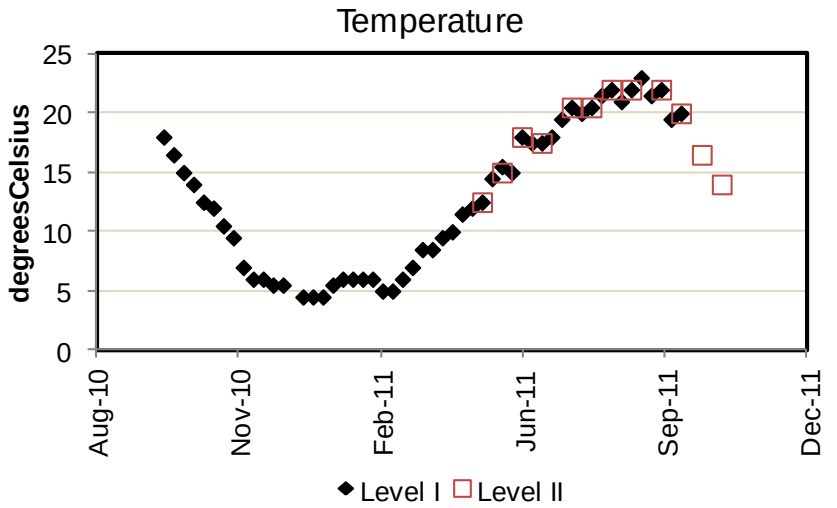

Figure 3. WY 2011 Lake Wilderness Temperature

Nutrients and Chlorophyll (Lake Wilderness)

Phosphorus and nitrogen are naturally occurring elements necessary in small amounts for both plants and animals. However, many actions associated with residential development

can increase concentrations of these nutrients beyond natural levels. In lakes of the Puget Sound lowlands, phosphorus is often the nutrient in least supply, meaning that biological productivity is often limited by the amount of available phosphorus. Increases in phosphorus concentrations can lead to more frequent and dense algae blooms – a nuisance to residents and lake users, and a potential safety threat if blooms become dominated by species that can produce toxins. Samples collected by volunteers are analyzed for total phosphorus (TotP) and total nitrogen (TotN) concentrations at one meter depth.

Total nitrogen started high and decreased from May through August, after which it remained fairly steady through the end of the sampling period. Total phosphorus remained steady through August and then increased slowly until October when it had a moderate jump at the end of the sample period (Figure 4). The N:P ratio ranged from 16.4 to 91.3, averaging 58.2 over the whole season, which is a higher average than previous seasons suggesting conditions were generally not conducive to bluegreen algae growth. Although as TP increased and TN decreased, the ratio dropped to 16.4 which may signal that conditions in the fall were better for nuisance bluegreen growth. This was confirmed when a moderate bluegreen bloom developed in mid October. Cyanobacteria (bluegreen algae) in the lake will be discussed in a later section.

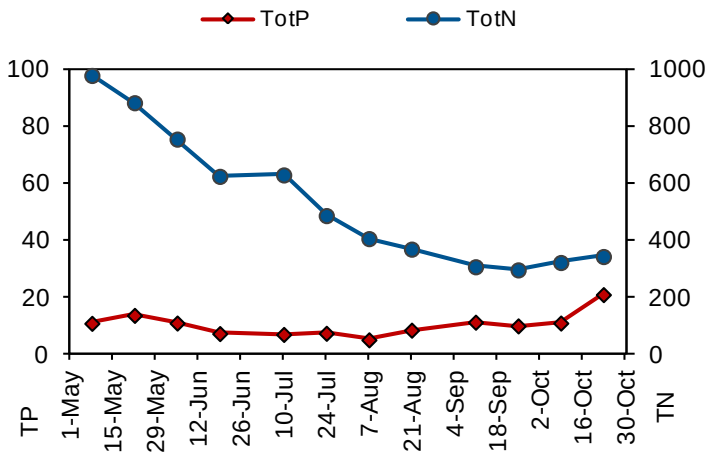

Figure 4. 2011 Lake Wilderness Total Phosphorus and Total Nitrogen Concentrations

Chlorophyll *a* remained decreased from May through July; it remained low during most of the summer and then began to climb steadily from early September through the end of the sampling period in October. Pheophytin, which is degraded chlorophyll, levels stayed at or below the minimum detection level.

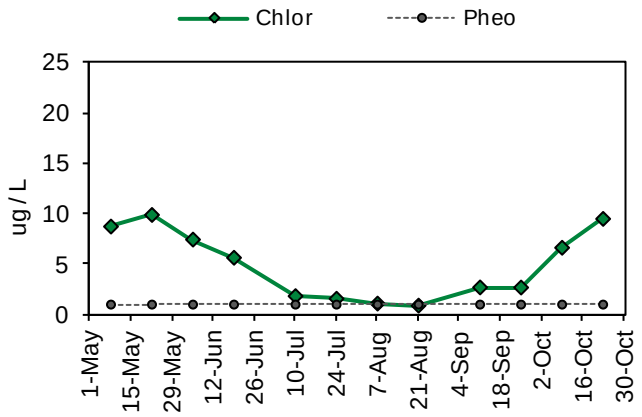

Figure 5. WY 2011 Lake Wilderness Chlorophyll *a* and Pheophytin concentrations

Profile data indicate that thermal stratification was present early in the season and persisted through the summer, though the deep water showed a temperature increase by the end of August. In the May profile event, phosphorus and ammonia were building in the deep water sample, which suggests the deeper water had low oxygen conditions contributing to nutrient recycling from the sediment. The lower values in the deep water in August, coupled with the warmer temperature, suggest that some water exchange between the thermal layers had already occurred, thus making deep water nutrients available to the phytoplankton in late summer. While chlorophyll was fairly evenly distributed through the water column in May, it was more concentrated in the deeper water in August, and this may be related to the mixing of the water column as well.

Table 1. Lake Wilderness Profile Sample Analysis Results. Sample values below minimum detection level are marked <MDL.

Lake name	Date	Secchi	Depth	DegC	Chlor-a	Pheo	Total N	NH3	Total P	OPO4	UV254	Total Alk
Wilderness	5/22/11	3.5	1	15.0	9.9	<MDL	0.884	0.010	0.0136	0.0032	0.038	40.8
Wilderness	5/22/11		4	13.0	15.0	<MDL	1.200		0.0216			
Wilderness	5/22/11		8.5	9.0	12.0	2.7	0.930	0.067	0.1360	0.0036		
Wilderness	8/21/11	8.0	1	22.0	0.9	<MDL	0.369	0.016	0.0084	<MDL	0.033	47.5
Wilderness	8/21/11		4	21.5	0.8	<MDL	0.387		0.0082			
Wilderness	8/21/11		8.5	12.5	28.0	14.9	0.643	0.034	0.0759	0.0086		

Alkalinity, also known as acid neutralizing capacity, was higher than in Pipe and Lucerne Lakes, suggesting that sources in the Wilderness watershed contain more dissolved salts that contribute to buffering capacity. Water color (UV254) was lower than Pipe and Lucerne, contributing to the exceptional water clarity and indicating that dissolved organic carbon from the surrounding watershed was not abundant in the lake water.

TSI Ratings (Lake Wilderness)

In 2011, the average TSI-Secchi was in the high range of oligotrophy, although the TSI for chlorophyll was mesotrophic and the Secchi TSI was on the threshold of mesotrophy. (Figure 6). This disparity among TSI values has been persistent over the years of monitoring, with water clarity predicting lower algal biovolumes than those predicted by the chlorophyll and phosphorus indicators. However, in the last few years, clarity has

decreased slightly, which leads to higher TSI values, while phosphorus also has decreased (which leads to lower TSI values). There is a suggestion of a downward trend in the phosphorus TSI. The correlation coefficient of a regression line fit through the values indicates it is a moderately good representation of a downward trend ($r^2 = 0.497$), which means that there is variability from year to year, but that for the period included in the analysis, about 50% of the variation can explained by a downward trend represented by the regression.

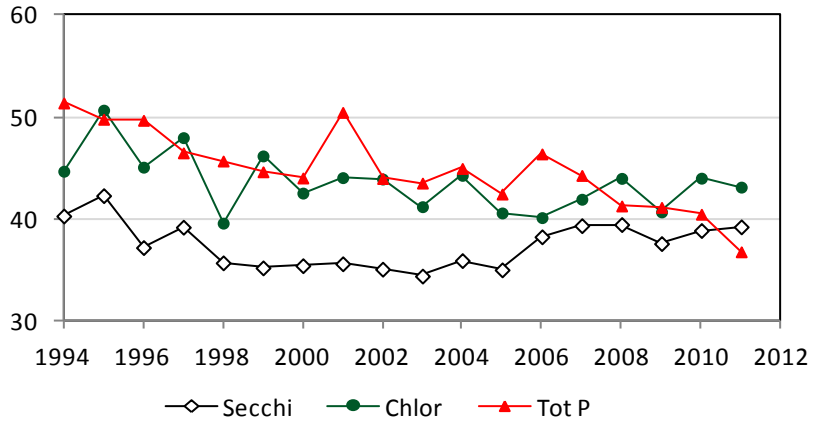

Figure 6. Lake Wilderness Trophic State Indicators

Lake Wilderness is exceptionally clear, and it may be that the type of algae doing well in the lake are those that produce buoyant colonies making particles in the water rather than single celled algae that produce cloudiness when abundant. This could make the lake more susceptible to scum formations on the downwind shorelines than a lake that produces algae clouding the water, but which are not easily moved en mass by wind and waves. The average of the TSI values put Lake Wilderness on the threshold between oligotrophy and mesotrophy, likely a little lower in algal production than in previous years.

Cyanobacteria toxins

Because of its history of occasionally producing bluegreen (cyanobacteria) blooms, Lake Wilderness was chosen as one of 30 Puget lowland lakes to be studied as part of work funded by a grant from the Federal Center for Disease Control (CDC) to the Washington Department of Health, a collaboration between state agencies and King, Snohomish, and Pierce Counties. The study involved regular biweekly sampling at a selected site for bluegreen species abundance and toxicity between June and October for three consecutive years. Blooms were sampled as well when identified elsewhere in the lake other than the swimming beach; the routine sample site. Four algal toxins are measured: microcystin, anatoxin-a, saxitoxin and cylindrospermopsin.

In addition, the Washington Department of Ecology Algae Program was utilized to test samples for toxicity when they were collected on dates outside the study window.

The third year of toxicity testing began in late April in response to a request from the city to test for toxicity prior to the annual festivities planned for Opening Day of the fishing season on the lake. The April sample was tested by the King County Environmental Lab and, as this was not in response to a specific bloom report, the City of Maple Valley paid for the analysis. The sample came back below detectable limits for microcystin and anatoxin-a, and no city sponsored Opening Day activities were cancelled or revised.

Routine monitoring as part of the grant-funded Regional Examination of Harmful Blooms project began in June and continued on a biweekly basis through October (Figure 7). Half of these samples were below the detection limit for microcystin, while the other five had negligible amounts, well below the 6 ug/L state guideline. Three other toxins tested for presence were not detected in any of the 2011 samples.

ROUTINE

Sample ID	Collect Date	Client Locator	Anatoxin-a VALUE (ug/L)	Anatoxin-a MDL (ug/L)	Cylindrospermopsin VALUE (ug/L)	Cylindrospermopsin MDL (ug/L)	Microcystin VALUE (ug/L)	Microcystin MDL (ug/L)	Saxitoxin Value (ug/L)	Saxitoxin MDL (ug/L)
L53006-6	5-Jun-11	WILDERNESS	<.0185	0.0185	0.1	0.1	0.05	0.05	0.02	0.02
L53009-6	19-Jun-11	WILDERNESS	<.0185	0.0185	0.1	0.1	0.05	0.05	0.02	0.02
L53010-6	10-Jul-11	WILDERNESS	<.0185	0.0185	0.1	0.1	0.05	0.05	0.02	0.02
L53011-6	24-Jul-11	WILDERNESS	<.0185	0.0185	0.1	0.1	0.05	0.05	0.02	0.02
L53528-6	8-Aug-11	WILDERNESS	<.0185	0.0185	0.1	0.1	0.05	0.05	0.02	0.02
L53529-6	21-Aug-11	WILDERNESS	<.0185	0.0185	0.1	0.1	0.0525	0.05	0.02	0.02
L53530-6	11-Sep-11	WILDERNESS	<.0185	0.0185	0.1	0.1	0.095	0.05	0.02	0.02
L53531-6	25-Sep-11	WILDERNESS	<.0185	0.0185	0.1	0.1	0.26	0.05	0.02	0.02
L53532-6	9-Oct-11	WILDERNESS	<.0185	0.0185	0.1	0.1	0.204	0.05	0.02	0.02
L53533-6	23-Oct-11	WILDERNESS	<.0185	0.0185	0.1	0.1	2.41	0.05	0.02	0.02

BLOOMS

Sample ID	Collect Date	Client Locator	Sample Info	Anatoxin-a VALUE (ug/L)	Anatoxin-a MDL (ug/L)	Cylindrospermopsin VALUE (ug/L)	Cylindrospermopsin MDL (ug/L)	Microcystin VALUE (ug/L)	Microcystin MDL (ug/L)	Saxitoxin VALUE (ug/L)	Saxitoxin MDL (ug/L)
L54443-1	14-Oct-11	WILKI03_11-01	WILDERNESS	<.0185	0.0185			1.04	0.05		
L54518-3	23-Oct-11	WILKI01_11-02	WILDERNESS	<.0185	0.0185	0.1	0.1	3.78	0.05	0.02	0.02
L54648-1	10-Nov-11	WILKI03_11-03	WILDERNESS					0.481	0.05		

OPENING DAY

Sample ID	Collect Date	Client Locator	Anatoxin-a VALUE (ug/L)	Anatoxin-a MDL (ug/L)	Microcystin VALUE (ug/L)	Microcystin MDL (ug/L)
L53063-1	4/25/2011	WILDERNESS	<.0185	0.0185	0.05	0.05

Figure 7. Cyanobacteria toxicity test results. All values in µg/L. <MDL means below minimum detection level.

Three bloom samples were taken in fall of 2011 due to scum accumulations. This was during the period of time when the N:P ratios were lowest and the likelihood was increased for increases in potentially toxic bluegreen algae. Testing the scums did produce measureable amounts of the toxin microcystin, but the highest it reached was 3.78 ug/L, which is below the 6 ug/L recommended state guideline. The City followed the Washington Department of Health guidelines and posted Caution signs along the beach as a way to communicate to the public that toxic algae had been found in the lake and agencies were recommending avoidance of scum accumulations. None of the other three toxins were found in Lake Wilderness.

Conclusions and Recommendations

Based on monitoring data, water quality in Lake Wilderness appears to be fairly stable over the period measured, with a long term trend toward decrease in phosphorus concentrations validated over the period measured. Low N:P ratios in the fall indicate conditions can be favorable during that season for nuisance bluegreen algae which was validated by the fall onset of slightly toxic algal scum accumulations along shorelines. The lake water clarity suggests that those blooms are taking the form of large buoyant colonies that make particles in the water, thus favoring accumulations along downwind shorelines.

Close monitoring of algae blooms at the lake, particularly in the fall should continue, including participation in the CDC grant project and the Washington State Department of Ecology's Toxic Algae Monitoring program, to determine how frequently the blooms at the lake produce toxins and how often the concentrations are above the draft state guidelines for recreational activities.

There is a downward trend suggesting total phosphorus is decreasing that has moderate statistical validation, and concentrations should continue to be monitored to determine if this may be a strong long-term trend. Over time, it may contribute to an increase in the N:P ratio, which could make the lake less hospitable to bluegreen blooms.